

Appendix B

The following pages 12-15 of the present Request for Continued Examination and Response Under 37 C.F.R. §1.114 contain a full set of the claims currently pending in application, including all amendments made herein and previously, in application Serial Number 09/819,296, filed March 27, 2001

8. A method of manufacturing a multi-layered barrier metal thin film by atomic layer chemical vapor deposition, comprising the steps of:

- providing a substrate in a reactant chamber;
- providing a first chemical species in said reactant chamber;
- providing a second chemical species in said reactant chamber,

wherein said first and second chemical species react to deposit a first layer of a barrier metal thin film of a first metal nitride on said substrate by atomic layer chemical vapor deposition;

- providing a third chemical species in said reactant chamber; and
- providing a fourth chemical species in said reactant chamber,

wherein said third and fourth chemical species react to deposit a second layer of said barrier metal thin film of a second metal nitride directly on said first layer by atomic layer chemical vapor deposition, wherein said second metal nitride is different from said first metal nitride,

wherein said barrier metal thin film deposited on said substrate defines a thickness of less than 100 Angstroms.

9. The method of claim 8 further comprising depositing a thin copper film on said barrier metal thin film.

10. The method of claim 8 wherein said thickness of said barrier metal thin film is equal to an atomic thickness of said first and said second metal nitrides.

12. The method of claim 8 wherein said first layer of said barrier metal thin film and said second layer of said barrier metal thin film are each chosen from the group consisting of TiN, TaN, W, WN and Si₃N₄.

13. The method of claim 8 wherein said substrate comprises a trench having a bottom surface and a side wall, and wherein said barrier metal thin film is deposited on said bottom surface and said side wall by atomic layer chemical vapor deposition such that said barrier metal thin film defines a blocking diffusion characteristic which is the same on said side wall and said bottom surface.

14. A method of manufacturing a multi-layered barrier metal thin film by atomic layer chemical vapor deposition, comprising the steps of:
providing a substrate in a reactant chamber;
providing a first chemical species in said reactant chamber;
providing a second chemical species in said reactant chamber,
wherein said first and second chemical species react to deposit a first barrier metal thin film of a first metal nitride on said substrate by atomic layer chemical vapor deposition;
providing a third chemical species in said reactant chamber;
providing a fourth chemical species in said reactant chamber,
wherein said third and fourth chemical species react to deposit a second barrier metal thin film of a second metal nitride directly on said first barrier metal thin film by atomic layer chemical vapor deposition, wherein said first metal nitride is different from said second metal nitride.

15. The method of claim 14 wherein said method is conducted at a temperature in a range of 300 to 600 °C, at a pressure in a range of 0.001 to 1.0 torr, and wherein each atomic layer chemical vapor deposition step is conducted for a time period in a range of 0.4 to 5.0 seconds.

16. The method of claim 14 further comprising providing a fifth chemical species in said reactant chamber and providing a sixth chemical species in said reactant chamber, wherein said fifth and sixth chemical species react to deposit a third barrier metal thin film of a metal nitride on said second barrier metal thin film by atomic layer chemical vapor deposition.

17. The method of claim 14 further comprising depositing a thin copper film on said second barrier metal thin film.

18. The method of claim 14 wherein said first barrier metal thin film and said second barrier metal thin film are each chosen from the group consisting of TiN, TaN, W, WN and Si₃N₄.

19. The method of claim 14 wherein said first barrier metal thin film and said second barrier metal thin film together define a layered structure having a thickness of less than 60 Angstroms.

20. The method of claim 14 wherein said first chemical species comprises a metal halide and said second chemical species comprises a nitrogen containing gas.

21. A method of manufacturing a multi-layered barrier metal thin film by atomic layer chemical vapor deposition, comprising the steps of:
providing a substrate in a reactant chamber;
depositing a first layer of a first metal nitride on said substrate by atomic layer chemical vapor deposition; and

depositing a second layer of a second metal nitride directly on said first layer by atomic layer chemical vapor deposition;

wherein said first metal nitride is different from said second metal nitride.

22. The method of claim 21 further comprising depositing a third layer of a third metal nitride on said second layer by atomic layer chemical vapor deposition, wherein said third metal nitride is different from said first and said second metal nitrides.

23. The method of claim 21 wherein said multi-layered barrier metal thin film deposited on said substrate defines a thickness of less than 100 Angstroms.

24. The method of claim 21 wherein said first and second metal nitrides are each chosen from the group consisting of TiN, TaN, W, WN and Si₃N₄.

25. The method of claim 21 further comprising depositing a third layer of said first metal nitride on said second layer by atomic layer chemical vapor deposition, and depositing a fourth layer of said second metal nitride on said third layer by atomic layer chemical vapor deposition such that said multi-layered barrier metal thin film comprises alternating layers of said first and second metal nitrides.